

Hydraulic and Hydrologic
Considerations in Planning Course

FLOOD RISK MANAGEMENT

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Objectives

- **To review for students:**
 - **An overview of the analyses typically used in Flood Risk Management (FRM) studies.**
 - **The type of data needs for H&H analyses.**
 - **Various types of FRM alternatives (structural and non-structural measures) and the expected impacts of the alternative types.**
 - **H&H outputs to the study team.**

References

- **EM 1110-2-1419, Hydrologic Engineering Requirements for Flood Damage Reduction Studies, 31 Jan 95**
- **EM 1110-2-1417, Flood Runoff Analysis, 31 Aug 94**

Flood Risk Management



H&H Steps in a Flood Risk Management Study

- Preliminary Investigations**
- Development of Basin Model**
- Hydraulic Studies**
- Calibrate Models to Existing Conditions**
- Frequency Analysis for Existing Land-Use Conditions**
- Future Without-Project Conditions**
- Alternative Evaluations**
- Hydraulic Design**
- H&H Outputs and Reporting**

Preliminary Investigations

- **Initial Preparation**
- **Obtain Study Area Maps (define watershed boundaries)**
- **Determine mapping, cross-section data, and high water mark requirements**
- **Field Reconnaissance**
- **Prepare Survey Request for mapping requirements and/or cross-sections and high water marks**

Initial Preparation

- **Scope Study Objectives and Purpose**
- **Study Team determine:**
 - H&H and Study Team requirements
 - Study Constraints (\$, Rights-of-way, etc)
- **Review Available Documents**
 - Previous USACE work (incl Recon studies)
 - USGS or other Federal Agency Reports
 - Local Studies and Other related materials
- **Collect Existing Data:**
 - Historic & Design Discharges
 - Discharge-Frequency Relationships
 - High Water Marks
 - Cross-Section, Bridge, and Culvert Data
- **Scope Major H&H Engineering Activities**

Surveying Requirements

- **Obtain study area maps.**
- **Determine required survey data needs**
- **Field Reconnaissance**
 - Interview sponsor, residents, local agencies
 - Finalize cross-section/mapping needs
 - Estimate initial roughness values for channels and overbanks
 - Photograph channels and floodplain, bridges, culverts, weirs, etc.
- **Prepare Survey Request for mapping requirements, cross-section data, and high water mark data**

Development of Basin H&H Models

- **Calibration of runoff parameters**
- **Delineation of subareas**
- **Subarea rainfall-runoff analysis of historic events**
- **Channel routing characteristics**
- **Reservoir routing (if present)**
- **Generate hydrographs**

Hydraulic Studies

- **Prepare water surface data**
- **Proportion discharges**
- **Check Elevations**
- **Obtain Rating curves**

Calibration of Models to Historic Events

- **Check Hydrologic Model**
- **Calibrate models to high water marks**
- **Adopt H&H model parameters for hypothetical frequency analysis**

Frequency Analysis for Existing Land-Use Conditions

- **Develop Frequency Curves for each stream gage**
- **Develop Frequency Storms**
- **Develop Frequency hydrographs using calibrated model**
- **Calibrate model of each frequency event to known frequency curves**
- **Develop analytical frequency curves for ungaged watersheds, if necessary**
- **Determine frequency water surface elevations and profiles from rating curves**

Future Without-Project Conditions

- **From future land-use planning data, identify extent of future urbanization**
- **Select future years in which to determine project hydrology**
- **Adjust model hydrology parameters for all affected subareas**
- **Model future conditions & determine revised discharge-frequency relationships in watershed**

Alternative Evaluations

- **Modify existing & future without-project models to simulate individual alternatives or components**
- **Model alternative features**
- **Evaluate effects of components on sediment regime**
- **Consider non-structural components**
- **Perform alternative evaluation and selection**

Hydraulic Design

- **Perform hydraulic design commensurate with the level of detail of the study**
 - **Reservoirs**
 - **Levees**
 - **Channel Improvements**
 - **Diversions**
 - **Pumping**
 - **Nonstructural Measures**

H&H Outputs

- **Evaluating alternatives** – supporting benefit and cost development.
- **Benefits:** Providing input to the economic models to determine existing damages, Future without Project damages, and damages prevented (Stage/Flow Frequency data).
- **Cost Analysis:** Hydraulic design of alternatives features for design/cost analysis

H&H Outputs

- **Supporting Benefit Analysis:**
 - Stage-Discharge Frequency data for Existing, Future Without-Project, and Alternative(s) Conditions
- **Supporting Cost Analysis:**
 - Hydraulic design of alternatives features for design/cost analysis
 - Alignment or Right-of-Way requirements
- **Environmental Impacts and Features**

**Don't Forget
Risk & Uncertainty
Analysis**

Risk & Uncertainty Analysis Outputs for Flood Risk Management Studies

- **From ER 1105-2-100, FRM studies will provide:**
 - **Estimate of NED (Net Economic Development) Benefits & Benefit/Cost Ratio for each alternative**
 - Include probability that Net Benefits are positive
 - Probability that B/C Ratio is at or above 1.0
 - **Expected Flood Risk Management Performance to include:**
 - Annual Exceedance Probability with associated estimates of uncertainty
 - Equivalent long-term risk of exceedance over 10-, 30-, and 50-years
 - Ability to contain specific historic floods
 - **Residual Risk - Expected annual probability of each alternative being exceeded.**

Developing FRM Alternatives

Developing FRM Alternatives

- **Team Effort**
 - Planning, Engineering, Environmental, Economics, Stakeholders, Project Mgmt, etc.
- **Define problem locations**
 - Causes of Flooding
 - Economic Damage Locations
 - Environmental Areas of Concern
- **Level of Detail**
 - Reconnaissance, Feasibility, CAP, etc.

Developing FRM Alternatives

- **Alternative Types**
 - **Structural Measures** – Physical modifications designed to reduce the frequency of damaging levels of flood inundation (*Get water away from people*).
 - **Non-Structural Measures** – Reduces flood damages without significantly altering the nature or extent of flooding (*Get people away from water*).

Structural Alternatives

- **Reservoirs**
- **Channels Improvements
(including natural stream
design)**
- **Levees and Floodwalls**
- **Diversions**
- **Pumps**

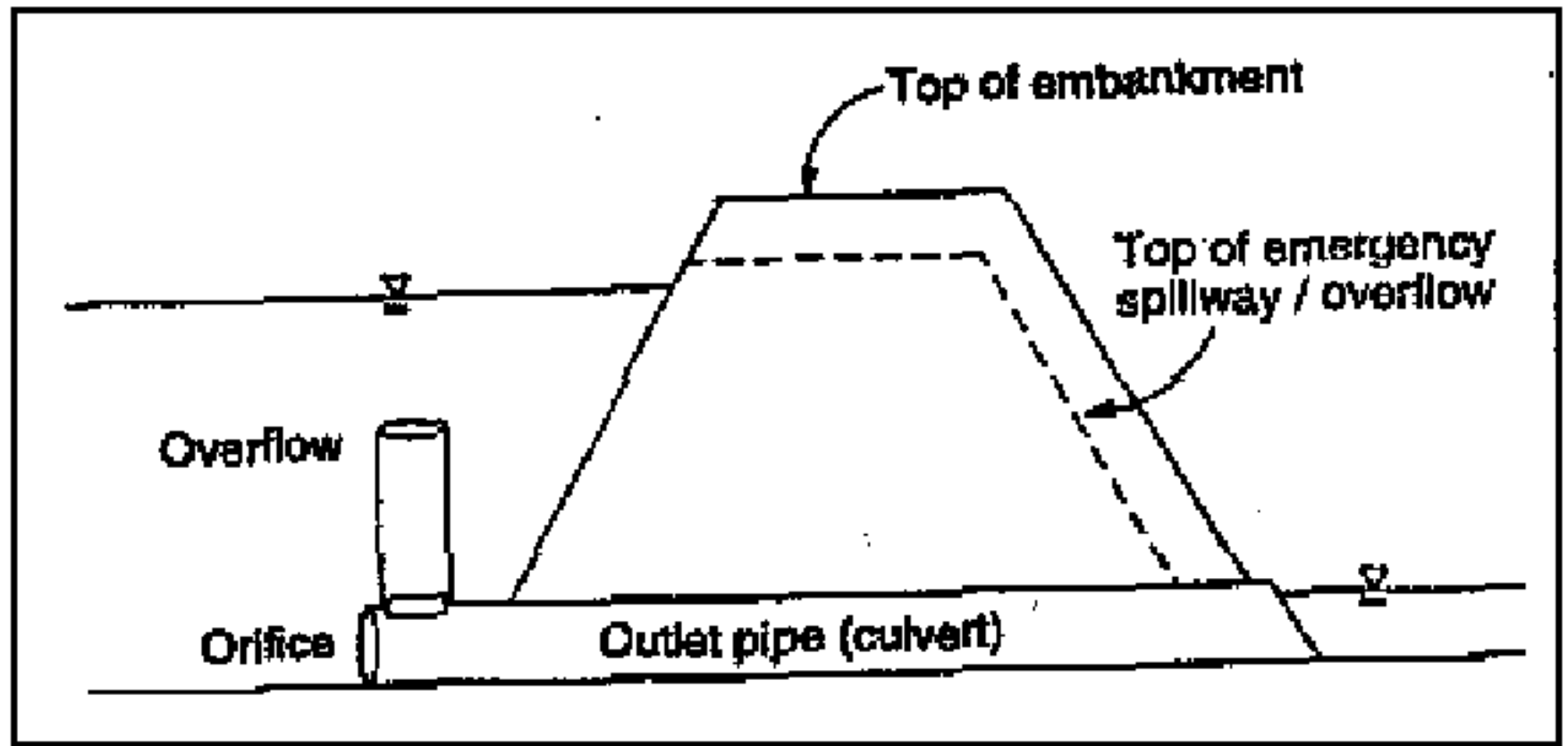
Non-Structural Measures

- **Flood Proofing**
- **House Raising**
- **Relocation**
- **Flood Warning & Evacuation**
- **Floodplain Regulation**

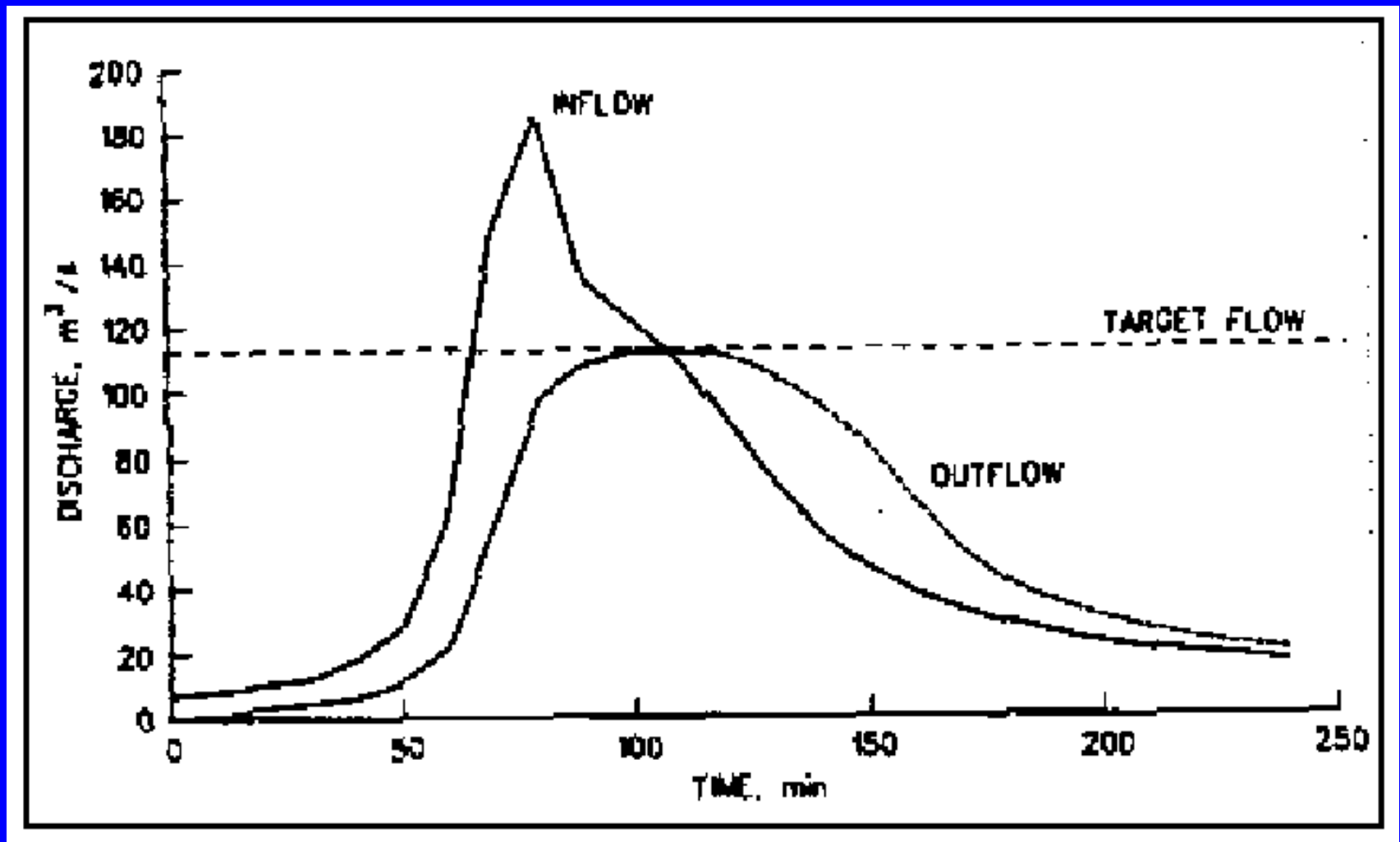
Dams and Reservoirs



Detention Ponds



Reservoir Hydrograph Impacts



Reservoir Impacts to Discharge-Frequency Curve

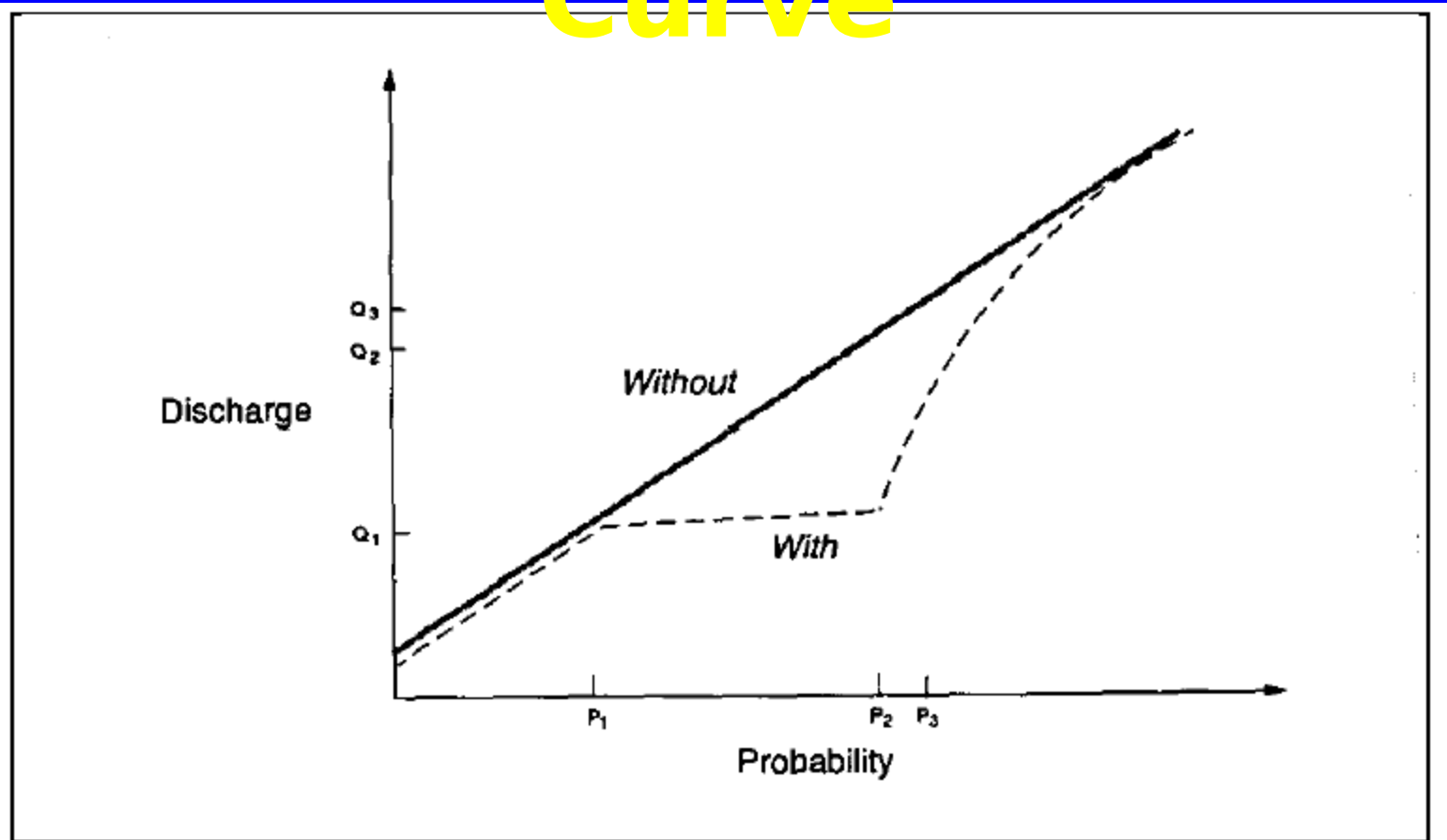


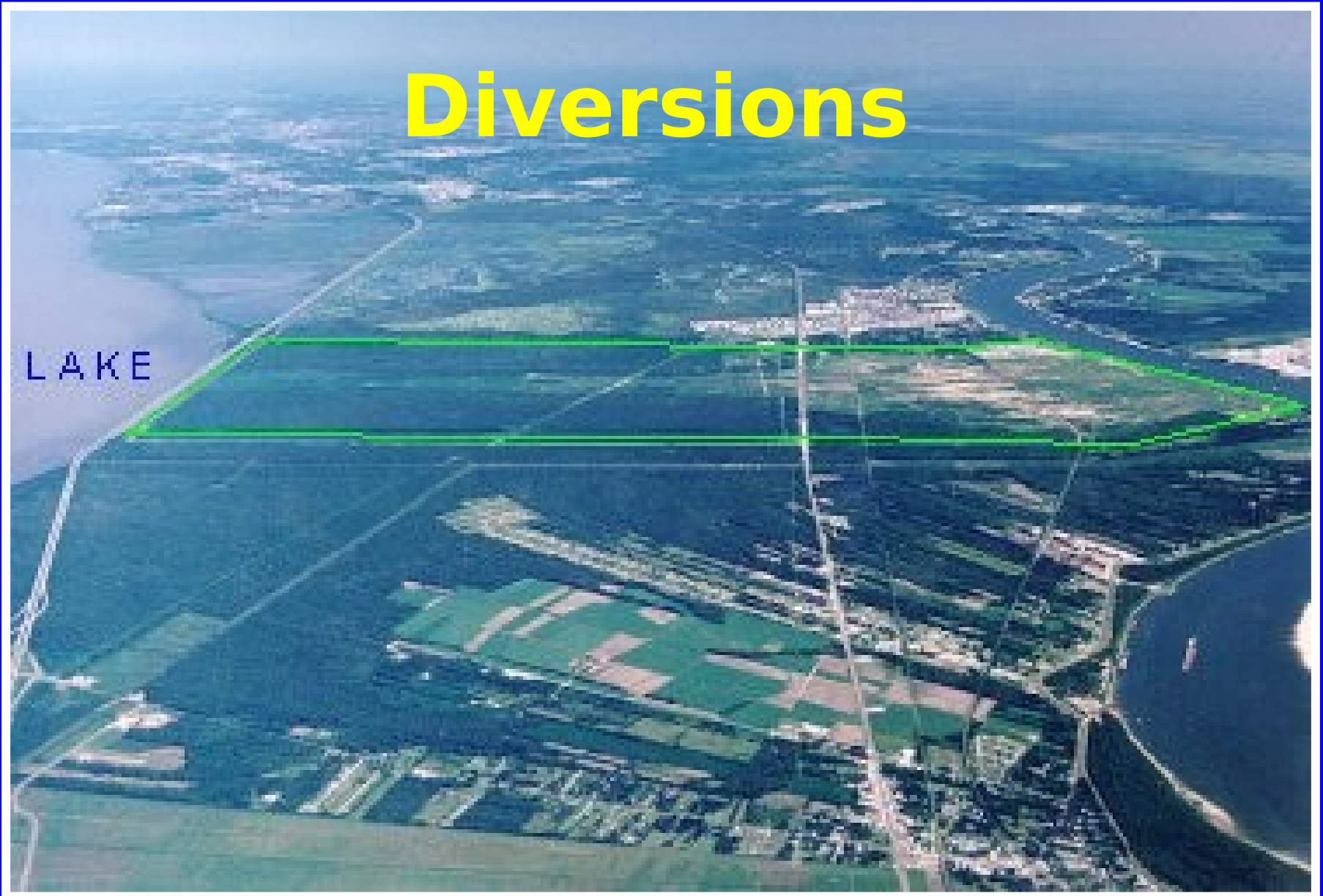
Figure 4-4. Discharge-frequency function modifications due to reservoir

Reservoirs & Dams

- **Performance Considerations**
 - Capacity, Configuration, and Location
 - Operation Rules
 - Other Considerations
- **Dry vs Wet Reservoirs**
- **Dam Safety Evaluation**
 - Minimize Hazard when Capacity is Exceeded
 - Failure Evaluation
- **Environmental Impacts**

Diversions

LAKE



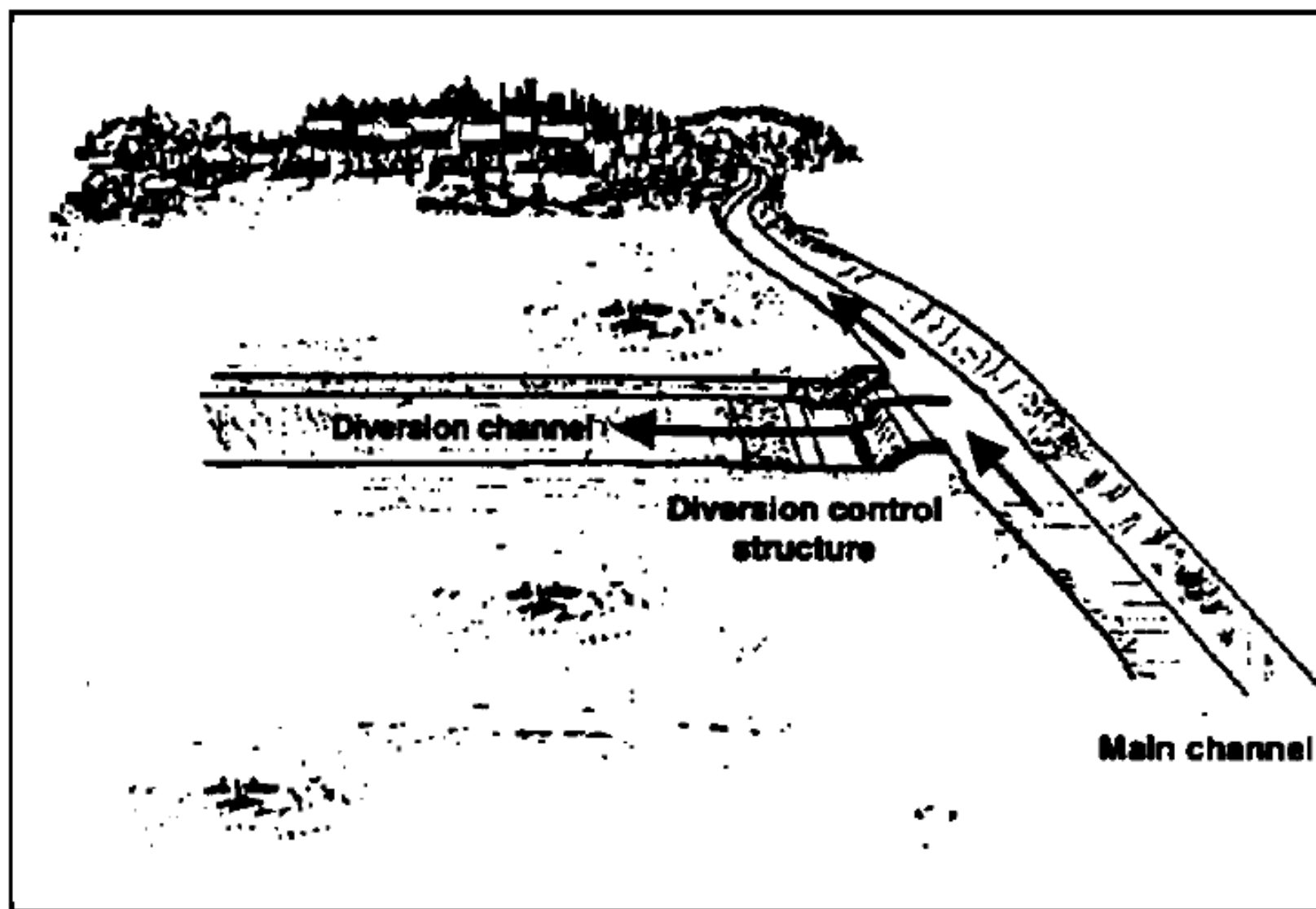


Figure 5-1. Major components of diversion

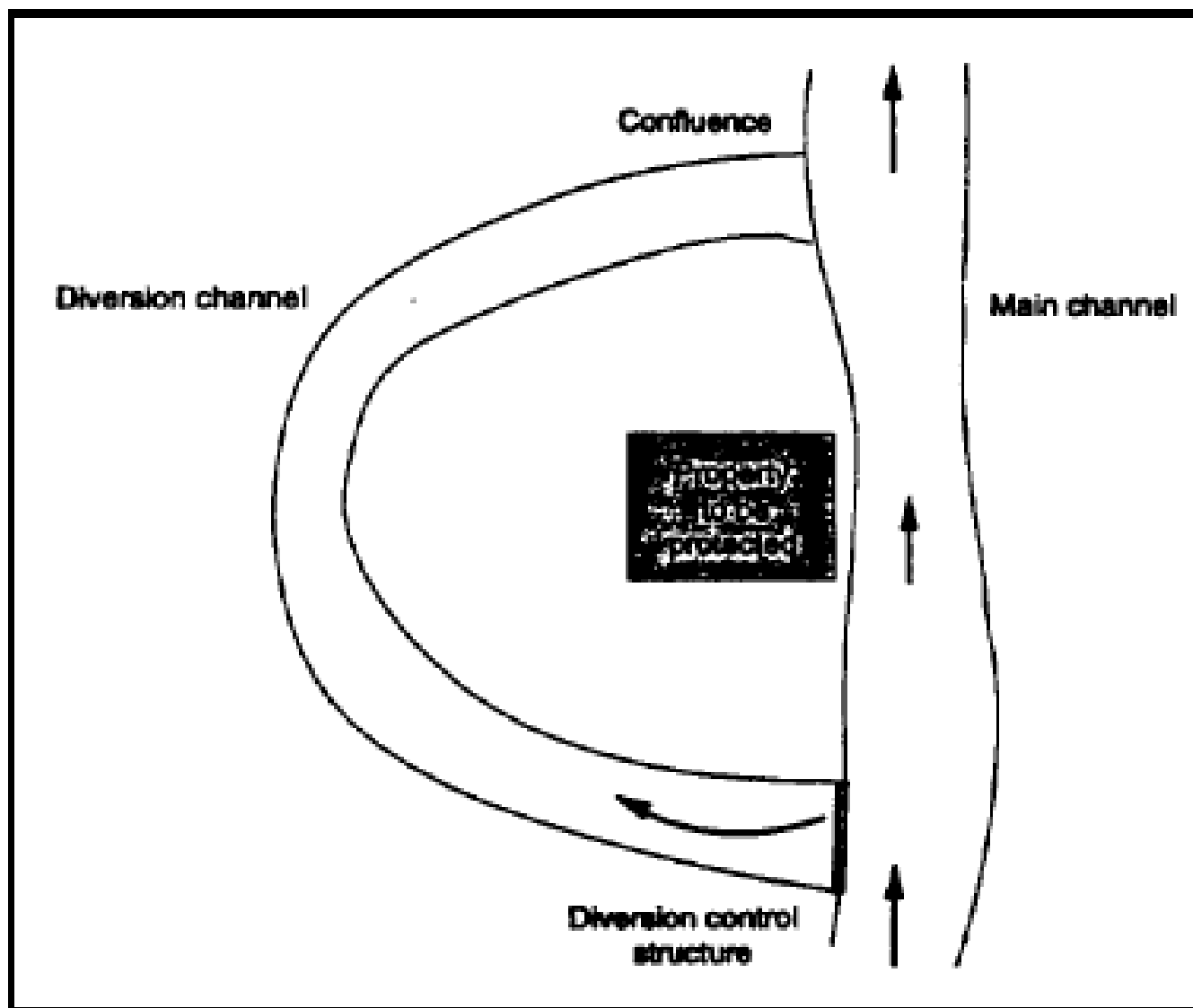


Figure 5-2. Plan view of diversion with downstream confluence

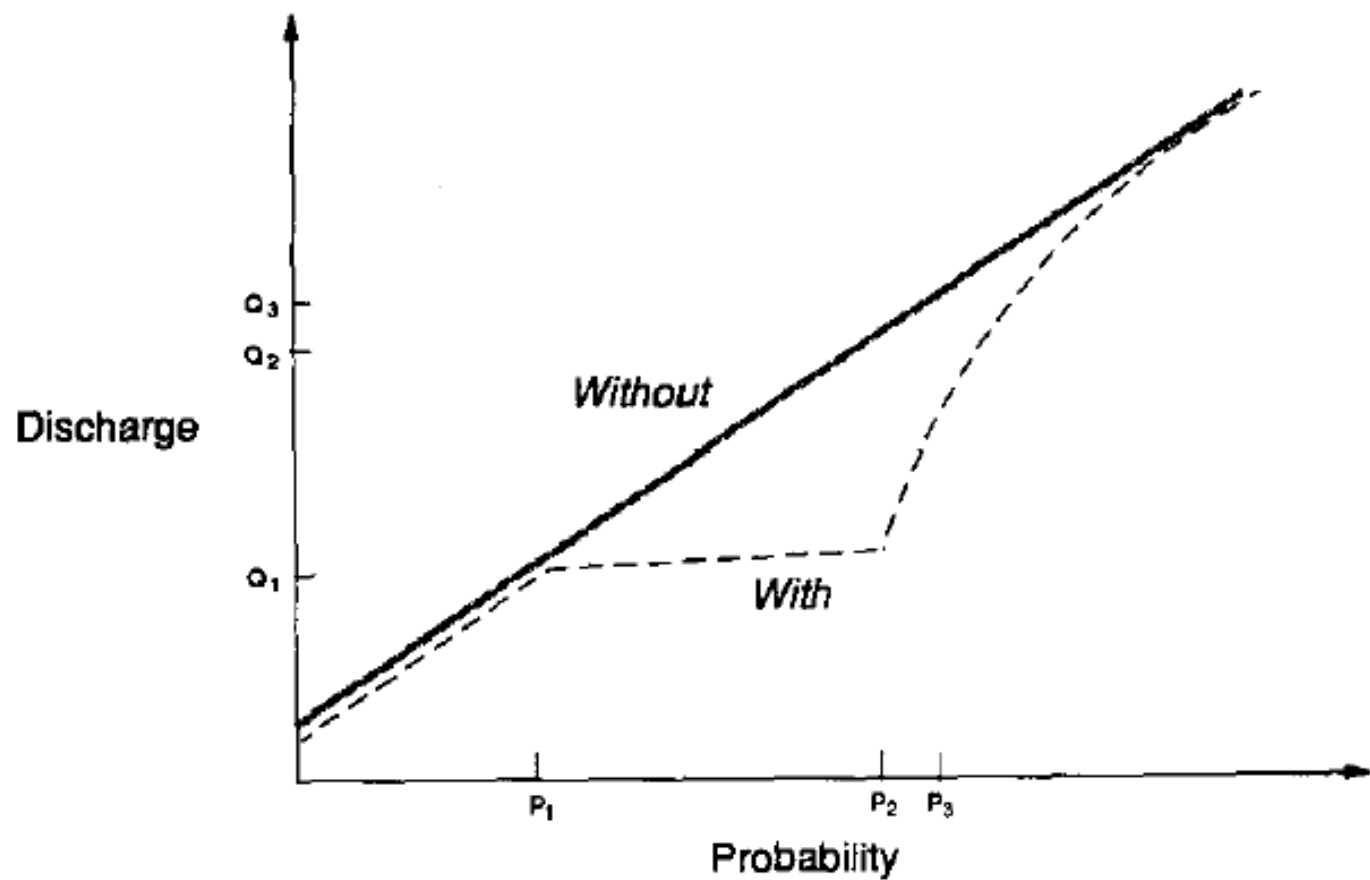


Figure 5-3. Discharge-frequency function modifications due to diversion

Channel Modifications



Channel Modifications



Channel Modifications



- **Types**
 - **Clearing & Snagging**
 - **Enlargement**
 - **Channel Lining (Concrete, Rock, etc.)**
 - **Realignment**

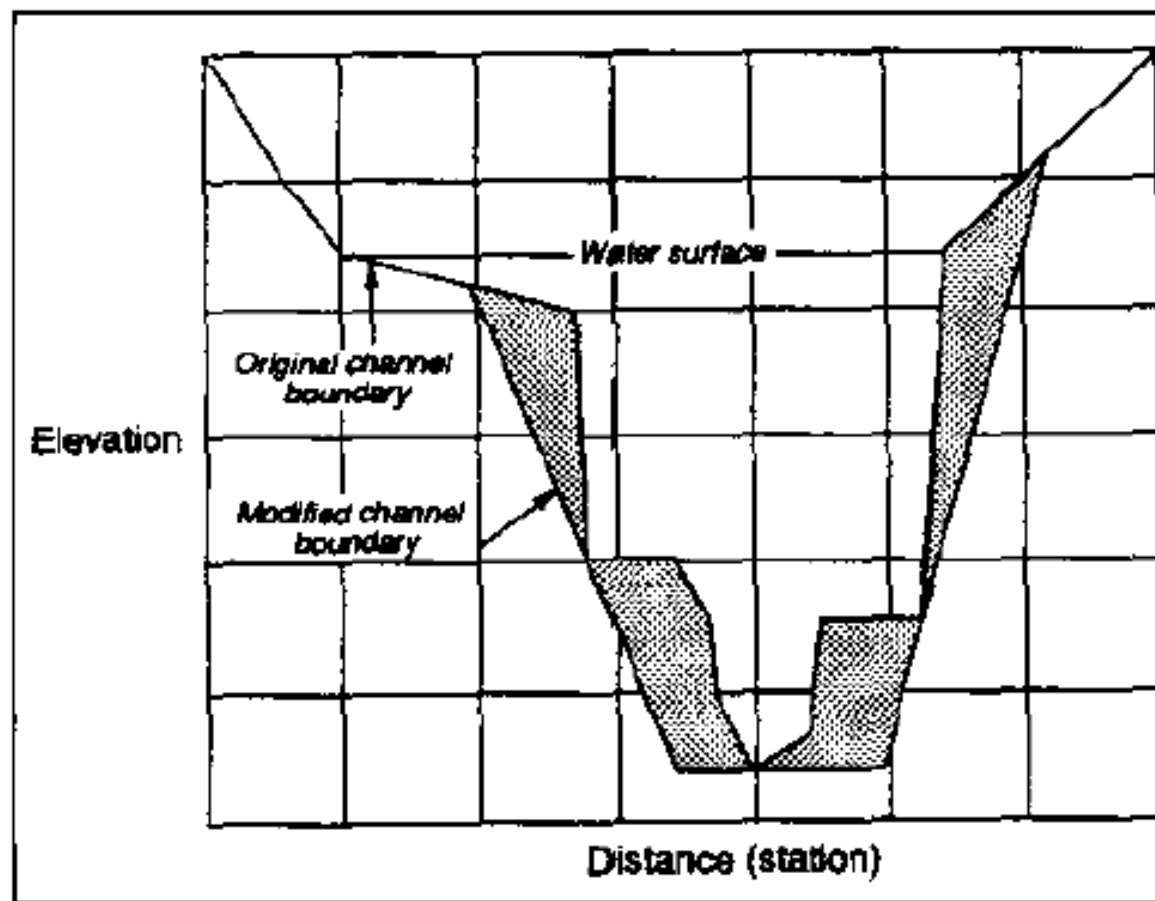


Figure 6-1. Illustration of channel geometry modification

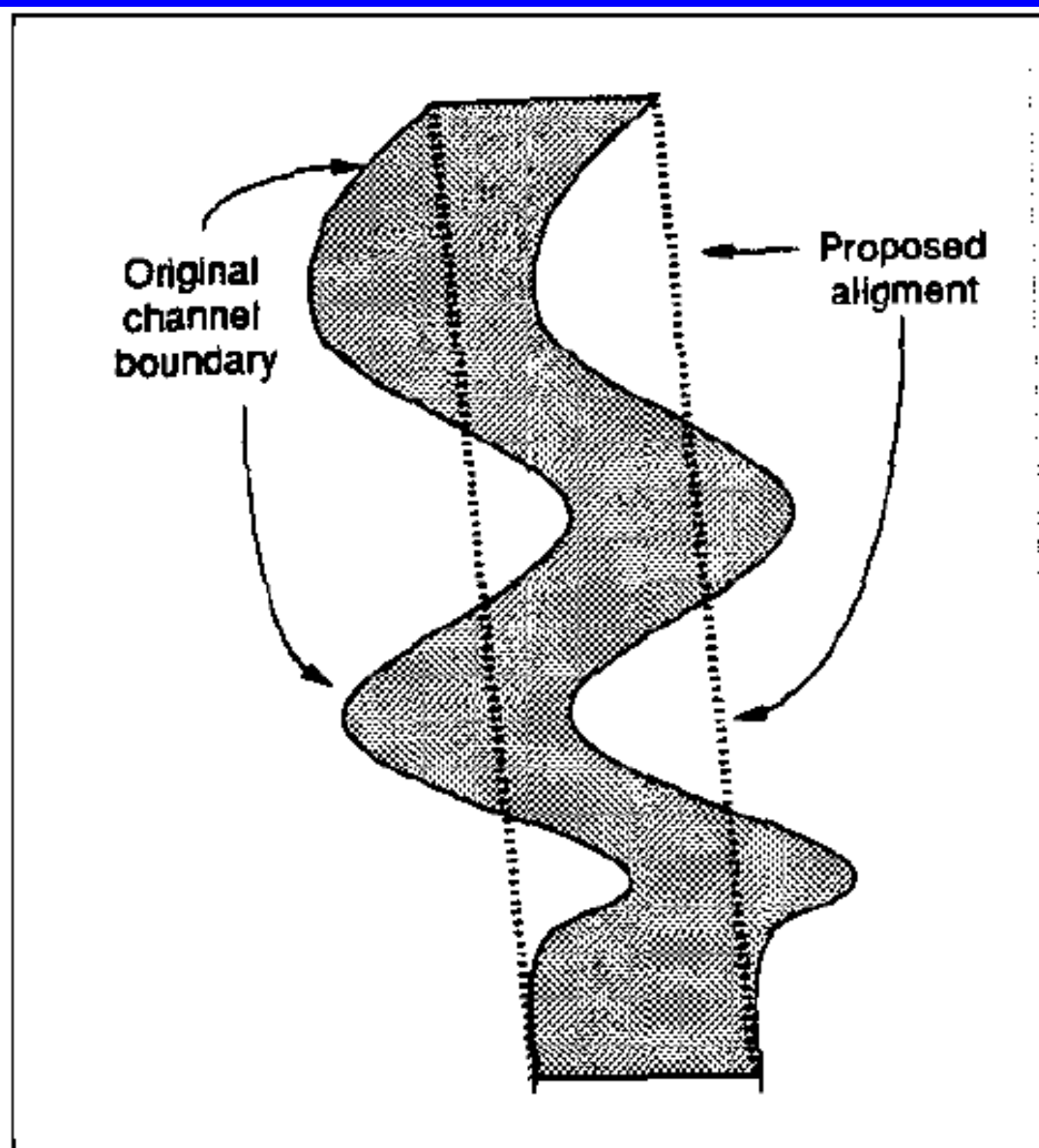


Figure 6-2. Channel re-alignment for damage reduction

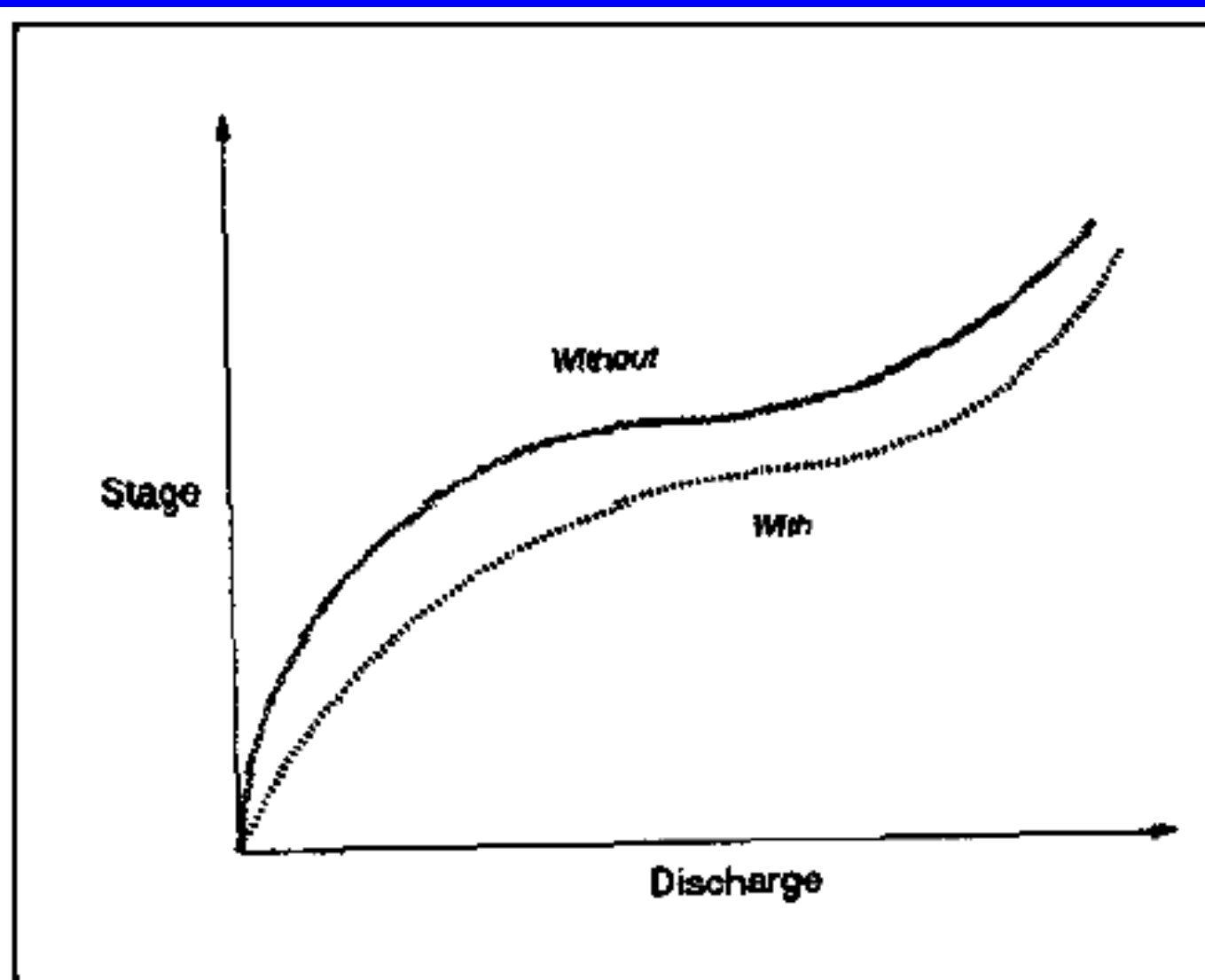


Figure 6-3. Stage-discharge function modifications due to channel improvement

Levees and Floodwall





Monroe, LA Folding Floodwall



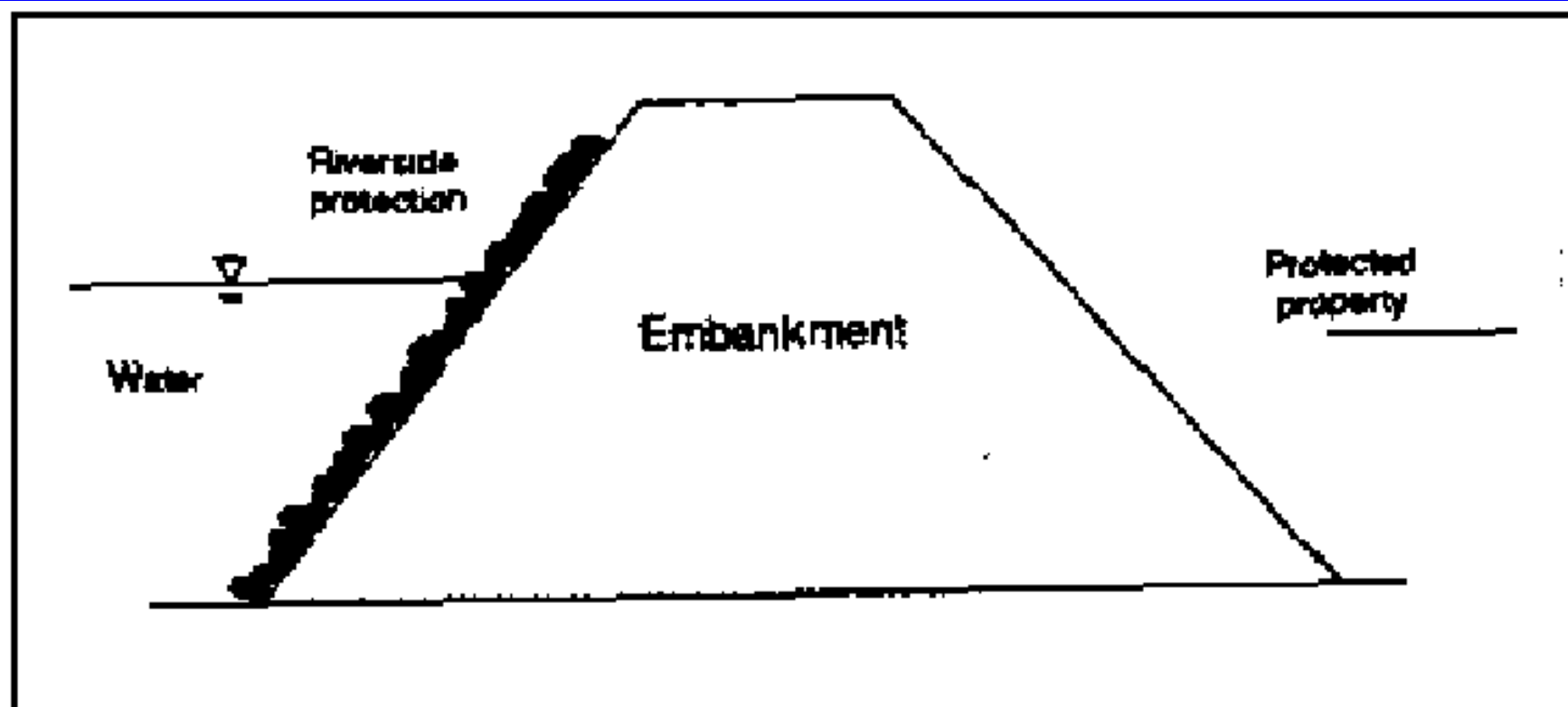


Figure 7-1. Cross section of simple levee

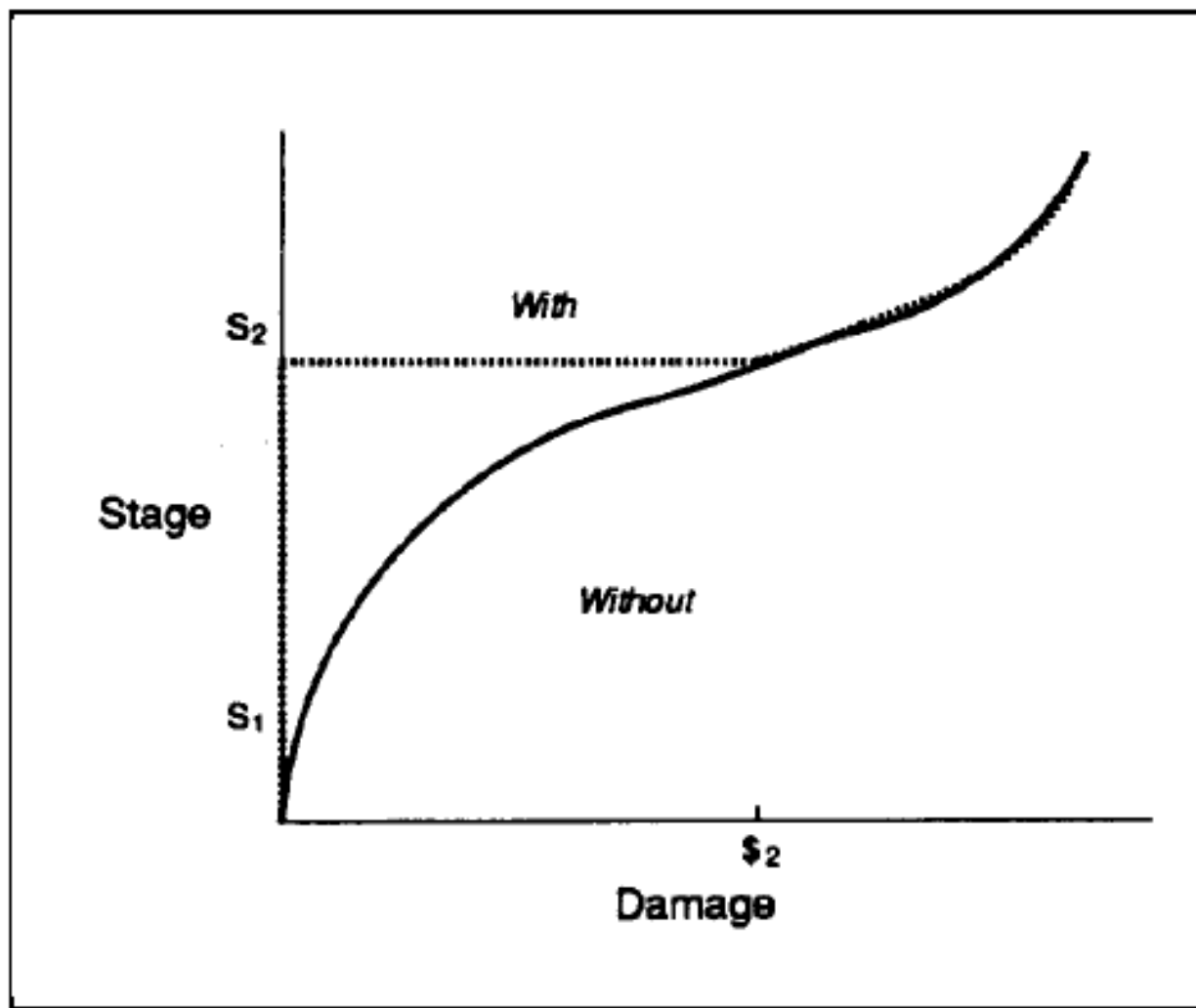


Figure 7-3. Stage-damage function modification due to levee/floodwall

Interior Drainage

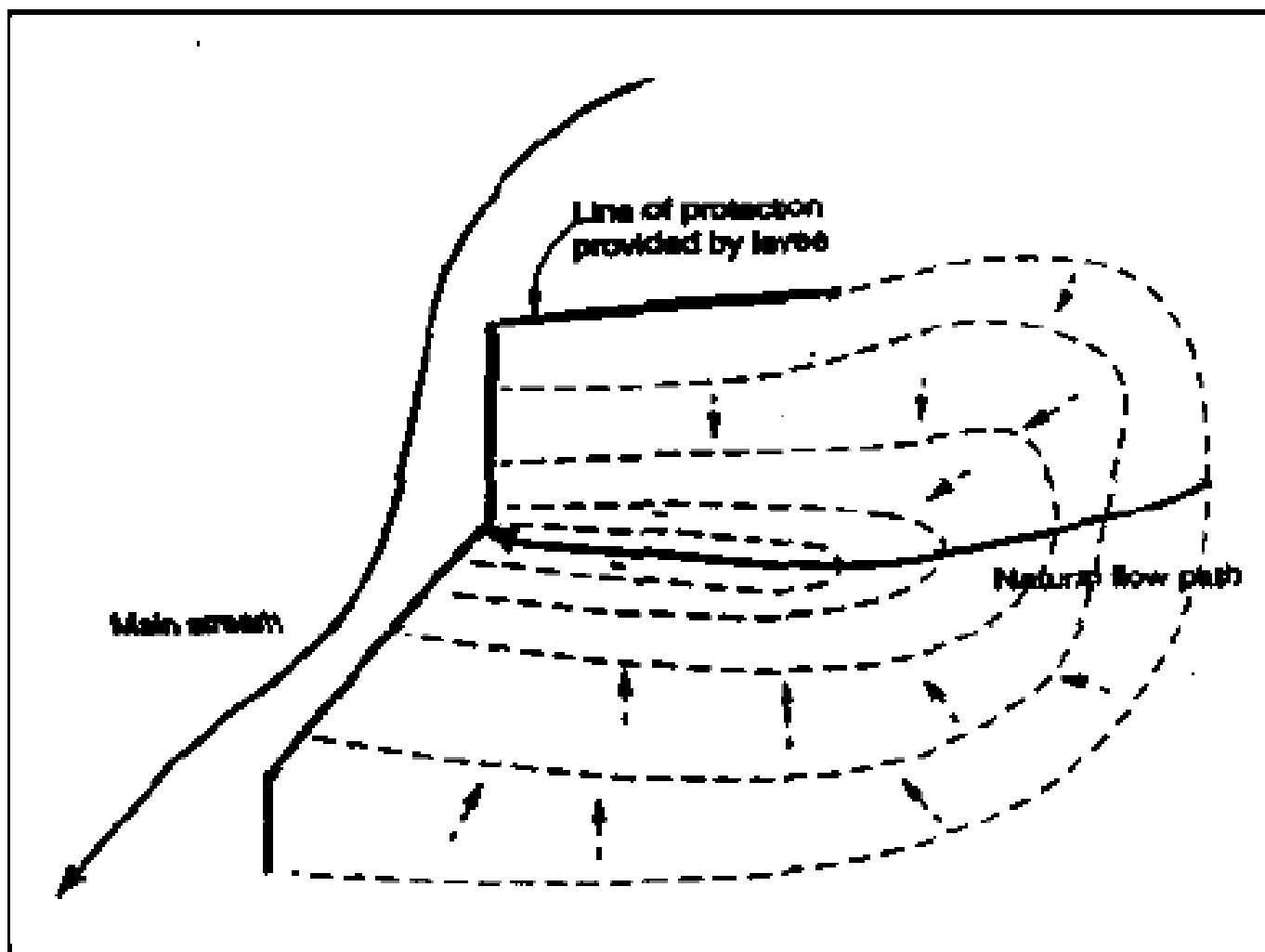


Figure 7-4. Plan view of levee with interior area

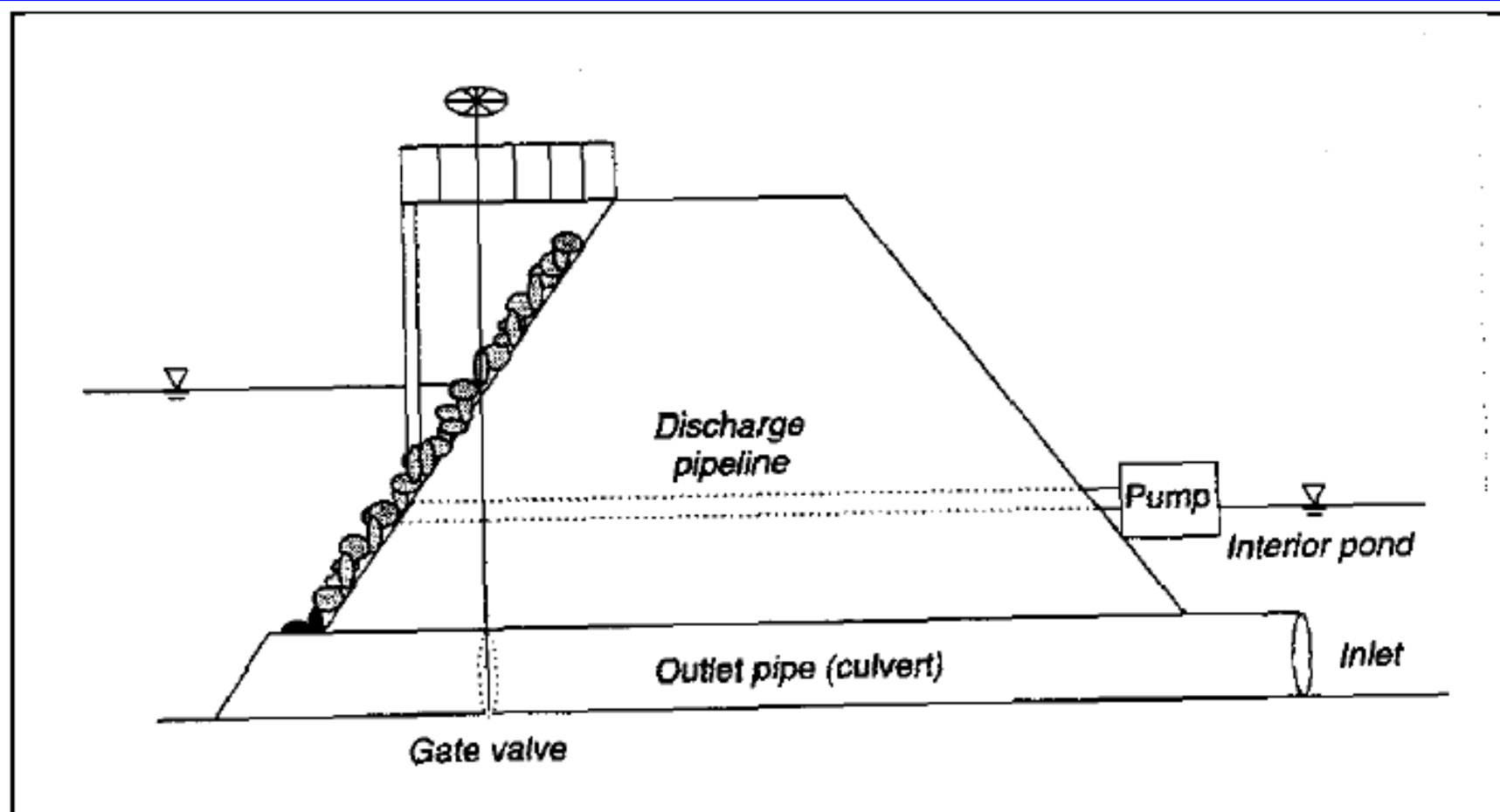


Figure 7-5. Components of interior-area protection system

PUMPS



PUMPS



Non-Structural Measures

- **Flood Proofing**
- **House Raising**
- **Relocation**
- **Flood Warning & Evacuation**
- **Floodplain Regulation**

Flood-proofing

- Depth of water in structure up to 2.5 feet
- Uses waterproofing and brick veneer in combination with waterproof closures over doors

Cost: \$15/sq. ft. of structure to be



Structure

Raising

- Depth of water in structure from 2.5 feet to 5 feet
- Physically raise houses by use of jacks
- Cost: \$50-\$100/sf of house (depending on 1 or 2 (200





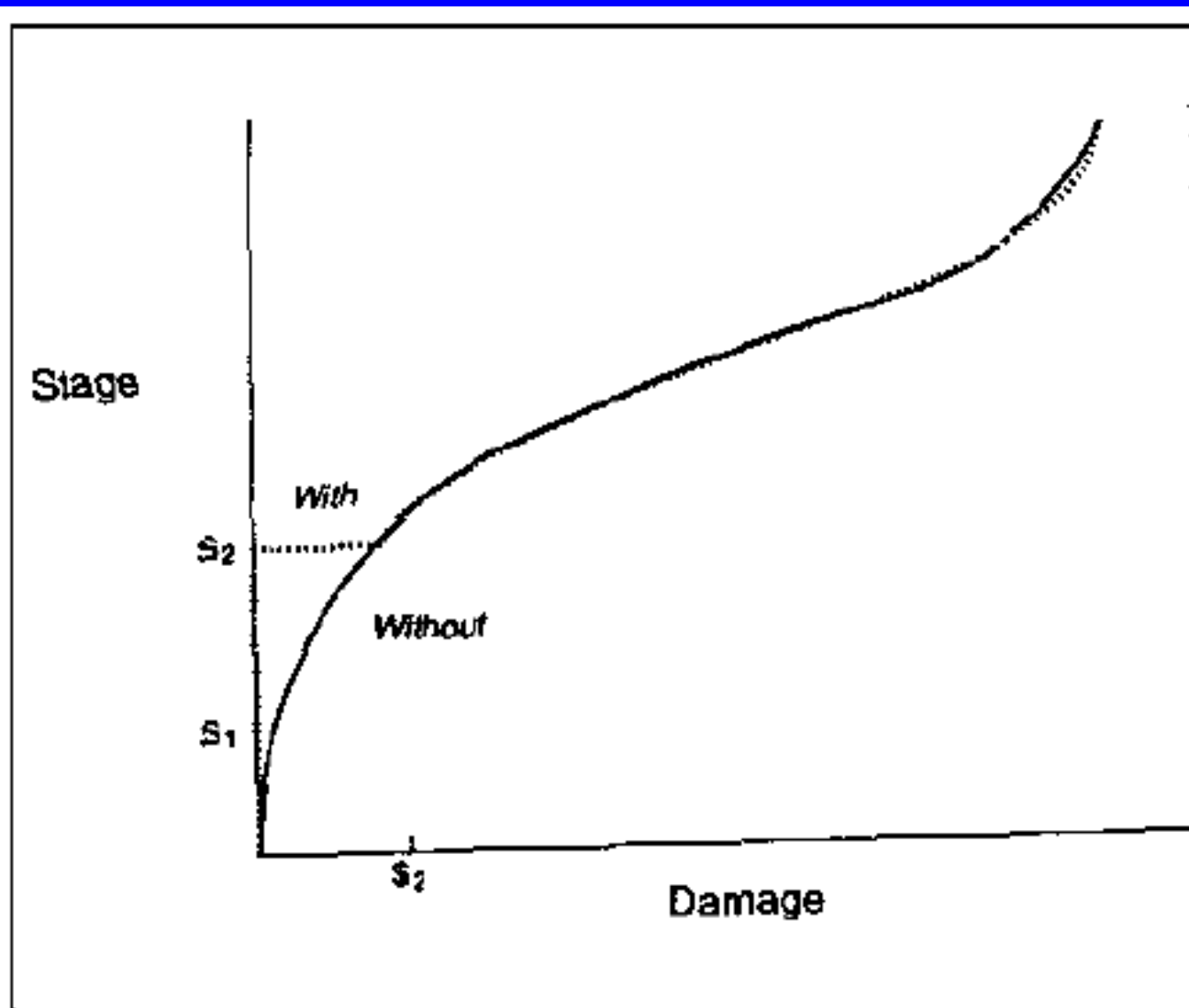


Figure 8-3. Stage-damage function modification due to floodproofing with closure, wall

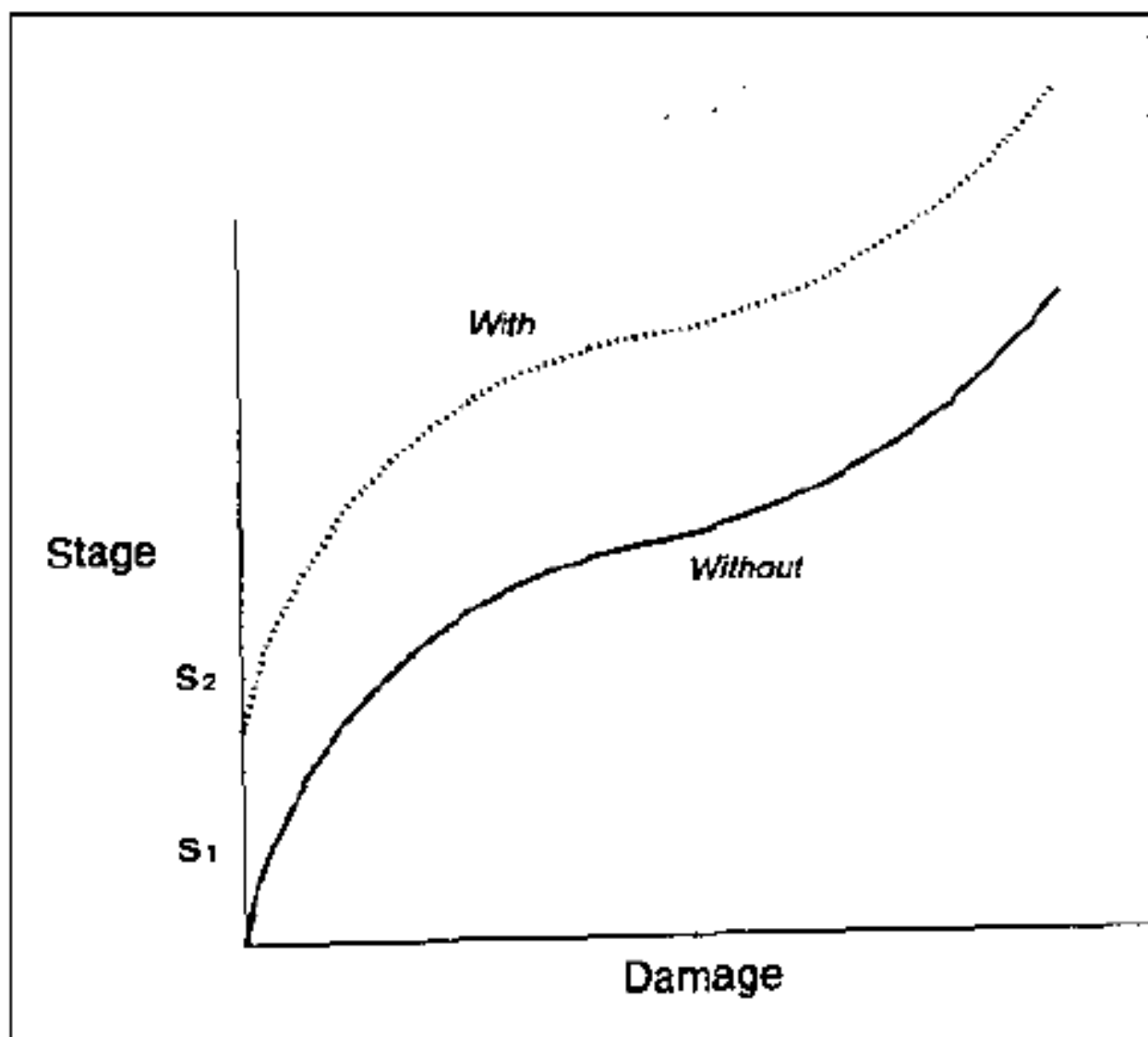


Figure 8-4. Stage-damage function modification due to floodproofing by raising in-place

Relocation

- **Moving property so it is less susceptible to damage from flooding. May be accomplished by:**
- **Relocating Contents within an existing structure at its current location**
- **Removing the contents or the structure and contents from a flood hazard area**

Flood Warning- Preparedness

- **May be implemented as:**
- **A stand alone measure when other measures are not feasible,**
- **An interim measure until others are in-place,**
- **A component of other measures**

Floodplain Regulation

- **Future-condition damage may be reduced through land-use and construction regulation or by acquisition. Although neither is used commonly in Corps flood damage reduction plans, both are potentially components of a complete plan in which costs are shared with local partners.**

Floodplain Regulation

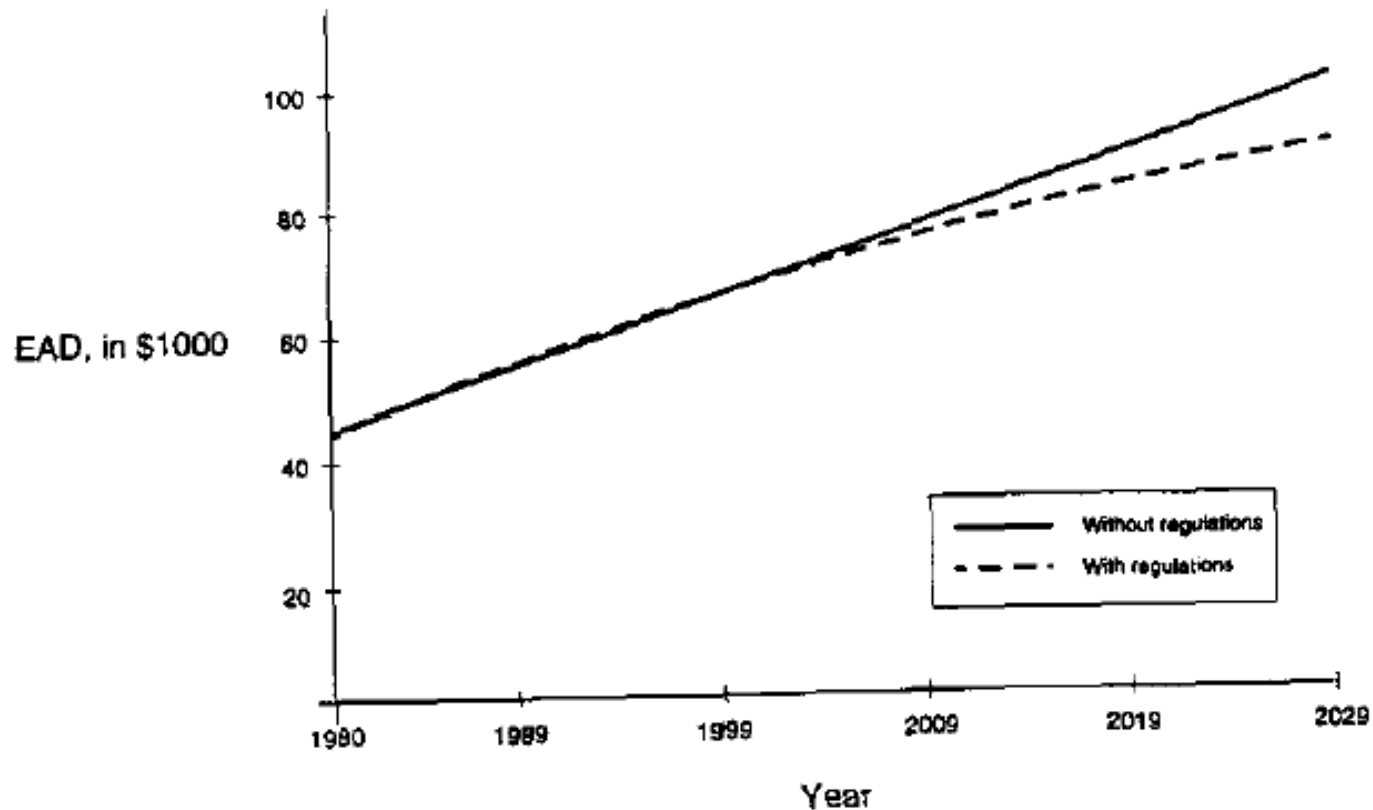


Figure 9-2. Illustration of regulation impact on future-condition EAD

Regional Differences for Flood Damage Reduction Measures

- **Ice & Snow**
- **Arid/Wet Climates**
- **Soil Infiltrations**
- **Social Likes/Dislikes**

Summary

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- **Questions/Discussion**